

**US Department of Energy  
General Motors Corporation  
and General Motors of Canada Ltd.  
Natural Resources Canada**

## **2000 ETHANOL VEHICLE CHALLENGE**

### **COMPETITION RULES and REGULATIONS**

**Issued 3/22/00**

**Argonne National Laboratory  
Center for Transportation Research  
9700 South Cass Avenue  
Argonne, IL 60439**

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## **1 INTRODUCTION**

The 2000 Ethanol Vehicle Challenge, an Advanced Vehicle Technology Competition (AVTC), will be held in Canada. Specific event locations are indicated in Section 8 of this document. The primary sponsors are the U.S. Department of Energy (DOE), General Motors Corporation (GM), and Natural Resources Canada (NRCan). The competition is administrated by Argonne National Laboratory (ANL). The objective of the 2000 Ethanol Vehicle Challenge is to further refine the existing student-engineered ethanol (E85) conversion of a 1999 Chevrolet Silverado. The competition trucks, supplied by General Motors prior to the 1999 Challenge, came equipped with a 5.3-L V-8 engine. The purpose of the 2000 Ethanol Vehicle Challenge is to advance the development of optimized, dedicated, ethanol (E85)-powered vehicles. The Challenge is intended to:

- Encourage innovation in ethanol (E85) vehicle technology, specifically in terms of vehicle performance, emissions control, fuel economy, and cold starting;
- Collect data to define the state of ethanol (E85) vehicle technology; and
- Provide student engineers with a valuable hands-on learning experience in a real-life interdisciplinary engineering project.

The 2000 Ethanol Vehicle Challenge involves comprehensive testing of the converted vehicles in events focusing on vehicle emissions, performance, cold start, design, and fuel economy. Participating teams are also required to document their research and conversion strategies in written reports.

## **2 ADMINISTRATION**

### **2.1 Main Contact**

The main contact for the 2000 Ethanol Vehicle Challenge is Cindy Svestka at Argonne National Laboratory. All documents must be sent to:

Cindy (McFadden) Svestka  
Argonne National Laboratory  
9700 South Cass Avenue, Building 362  
Argonne, IL 60439  
E-mail: [csvestka@anl.gov](mailto:csvestka@anl.gov)  
Phone: (630) 252-1353  
Fax: (630) 252-3443

### **2.2 Communication**

All questions will be answered through an e-mail list administrated by Argonne National Laboratory. The email system is the primary method of communicating with participants. All teams must have at least one key team member subscribed. It is highly recommended that teams have multiple subscriptions.

To subscribe to the e-mail list, send a message to **majordomo@anl.gov** including "subscribe ethanol-challenge" in the body of the message. After the subscription has been accepted, you can post a question at **ethanol-challenge@anl.gov**. Old messages may be found at the following URL address:

[gopher://gopher.anl.gov:70/11/ANL\\_Computing\\_info/ANL\\_Mailing\\_Lists/ethanol-challenge](mailto:gopher://gopher.anl.gov:70/11/ANL_Computing_info/ANL_Mailing_Lists/ethanol-challenge)

To unsubscribe from the e-mail list, send a message to **majordomo@anl.gov** including "unsubscribe ethanol-challenge" in the body of the message.

### **2.3 Team Selection**

All teams eligible for participation in the 2000 Ethanol Vehicle Challenge have already been selected and contacted.

### **2.4 Vehicle Requirements**

- a) The converted vehicle must be the 1999 Chevrolet Silverado donated to the school by the General Motors Corporation and used during the 1999 Challenge. No other vehicles will be permitted to compete.
- b) Schools must be the registered owners of their vehicles to be eligible to compete. The vehicle must be licensed in the school's state. It is the team's responsibility to obtain the registration and to pay any fees associated with the licensing of the vehicle.
- c) Each team must present evidence of current insurance coverage, at a minimum of \$100,000/\$300,000/\$100,000 (i.e., individual personal injury/total personal injury per accident/property damage), at the competition before they are allowed to compete.
- d) All legal documents (insurance, registration, etc.) must be in the vehicle at all times.
- e) The Organizers will reimburse the schools on a per-mile-traveled basis (\$0.32 per mile) for the transportation of each competition vehicle to Ottawa, Ontario, Canada (the starting point of the competition). The teams are responsible for paying their way to/from the competition.

### **2.5 Team Member Requirements**

- a) Each team must consist entirely of students, with at least 70% undergraduates, and at least one faculty advisor. For example, if there are 10 students working on the Challenge team, no more than 3 graduate students may be team members. Drivers during the event must be eligible students from the sponsoring university.
- b) All drivers must have a valid driver license.
- c) All participants must sign a liability waiver at registration in order to compete.

Student status is determined by the successful completion of two semesters or three quarters of full-time credit during the period between January 1, 1999 and June 30, 2000. Teams may have technical advisors from industry, but the

advisors may not be considered team members and are not allowed to perform the duties of a team member.

## 2.6 Faculty Advisor Requirements

- a) The Organizers recognize the team faculty advisor as the person listed as such on the Team Data Sheet (Appendix A).
- b) The team faculty advisor or representative from the school will be responsible for the student team members and **must be present throughout the competition** or the team will not be allowed to compete. **This rule will be enforced without exception.**
- c) A graduate student cannot act as a faculty advisor UNLESS he has the written authority to represent the school and make financial and legally binding decisions regarding students or vehicles. A formal letter must be sent to the Organizers explaining why the faculty advisor cannot be at the competition and naming a replacement. The letter must be on the official school letterhead and signed by the Dean or Department Head.
- d) The **Team Data Sheet** with address and phone number of the faculty advisors and a list of the student team members **must be received by Cindy Svestka by March 31, 2000**. The information will be used for communication, publicity, recruiting, and event planning.
- e) The faculty advisor must sign his/her team's design paper submittal and certify that all the modifications are trustworthy by signing the Modification Data Sheet submission (Appendix D).

## 2.7 Competition Sponsorship

**2.7.1 Definition of a Competition Sponsor.** A Competition Sponsor is defined as any organization that donates or makes available financial support, materials, or services equally to all teams. The sponsor's involvement will be determined individually by the Organizers. A Competition Sponsor differs from a Team Sponsor in that a Competition Sponsor must offer financial support, goods, and/or services to all teams. A Team Sponsor is one that provides financial support, goods and/or services to only one team. It is the responsibility of the Competition Sponsor to notify the Organizers regarding its level of involvement and sponsorship.

**2.7.2 Competition Sponsor Objectives and Responsibilities.** The objectives and responsibilities of Competition Sponsors include providing financial support AND/OR one or more of the following to all of the schools participating in the competition:

- Technical and logistical support, and hardware
- Equipment that will enhance the safety and quality of the competition
- Access to adequate materials to build high-quality vehicles to provide for a better competition
- Food, hospitality, and/or comparable in-kind contribution

**2.7.3 Sponsor Classification.** Any questions on sponsorship and sponsorship classification can be directed to Kristen De La Rosa at 512/481-8876. Sponsors will be classified according to the total value of the donation offered to participating schools. In-kind contributions donated in lieu of cash contributions must be approved by the Organizers.

**The following levels will be used:**

Headline Competition Sponsor	\$50,000+ (U.S.)
Major Competition Sponsor	\$20,000+ (U.S.)
Competition Supporter	\$10,000+ (U.S.)
Competition Event Sponsor	\$5,000+ (U.S.)

**2.7.4 Responsibilities of Participating Schools.** Schools participating in the 2000 Ethanol Vehicle Challenge have the following responsibilities:

- Act in good faith to ensure that no major vehicle systems or subsystems are designed or built by sponsors. This provision does not preclude schools from obtaining such components as engines, batteries, etc., from sponsors; it is aimed at discouraging sponsors from custom building a significant portion of the vehicle for the school;
- Verify that team sponsor's vehicle decals conform to the requirements of the Ethanol Vehicle Challenge Rules and Regulations;
- Upon acceptance of a donation, display sponsor decals on competing vehicle on the basis of sponsor classification;
- Honor Headline Sponsors by not applying decals from their competitors to competition vehicles.
- Acknowledge the Headline Sponsors in all team publicity efforts.

**Teams may not solicit additional funds from DOE, GM or Natural Resources Canada; they may, however, receive donations from privately-owned dealerships and subsidiaries of the auto company.**

## **2.8 Withdrawals**

If, in good faith, a team feels that it must withdraw from the Ethanol Vehicle Challenge, a formal letter of withdrawal is required. Withdrawals are final, and any team withdrawing from the competition may not reenter in a later date. The letter must be addressed to Cindy Svestka, and it must state the reason(s) for the decision to withdraw. The letter must be signed by the team's faculty advisor and the college dean.

## **2.9 Penalties for Non-participation in the 2000 Ethanol Vehicle Challenge**

Penalties are explained in the Donation Agreement signed by the schools when the vehicles were released.

### **2.10 Room and Board**

The Organizers will provide a list of hotels and lodging facilities in the Ottawa, Ontario, area (and any other cities associated with the competition, such as those included in the over-the-road event), but it is the school's responsibility to contact, make arrangements and pay for lodging of its team.

### **2.11 Event Officials**

The Organizers shall elect events captains and other officials for the Ethanol Vehicle Challenge who will be instructed in and responsible for the duties outlined below. The officials will have the authority and responsibility to apply and enforce the regulations described herein.

Events officials will be responsible for overseeing the overall coordination of an event, including (but not limited to) reporting all scores and penalties and for verifying compliance with the regulations. They will make all judgments and measurements including, but not limited to, safety, times, emissions content, fuel economy, and vehicle compliance with the rules. Event Officials will also have the right to inspect or re-inspect competition vehicles at any time during the competition.

### **2.12 Technical Committee**

The Organizers shall elect a Technical Committee for the Ethanol Vehicle Challenge that will be responsible for providing technical support to the schools, approving any body, transmission, or frame modifications, and clarifying any rules interpretation. Any question to the Technical Committee will be handled through the Ethanol Vehicle Challenge e-mail system.

## **3 CONVERSION REQUIREMENTS**

This section explains modifications permitted to the vehicle. All modifications to the vehicles must conform to the requirements of the Vehicle Safety Inspection Sheet (Appendix B). A copy of the Modification Data Sheet (Appendix D) must be sent to Cindy Svestka no later than April 28, 2000, or the school will be ineligible to participate in the competition. **The faculty advisor must certify that this information is correct by signing the Modification Data Sheet submission.**

### **3.1 Fuel and Fuel-System Components**

**3.1.1 Fuel.** The 2000 Ethanol Vehicle Challenge is based on using ethanol (E85) as the only vehicle fuel. A limited quantity of the fuel, identical to the fuel that will be used at the competition, will be supplied to each school for development purposes. The exact composition of the competition fuel is shown in Appendix C.

**3.1.2 Tanks and Fuel System.** The fuel system and fuel-system components shall be for dedicated ethanol (E85) use. Accepted industry practices for

liquid fuel systems should be followed. All materials used in the fuel system must be ethanol compatible; copper is not ethanol compatible and therefore not an acceptable fuel system material. Fuel system components must be mounted aft of the radiator support and within radiator support boundaries.

A list of the materials and components used in the fuel system (including fuel pump, o-rings, fuel lines, injectors and any other part that will be in direct contact with the fuel) shall be included on the Vehicle Modification Sheet (Appendix D). The use of components specific to the vehicle-conversion system (e.g., fuel metering device) will be allowed, as long as the team has proof of ethanol compatibility. All fuel system components should be identified on the fuel system diagram that must be included as an attachment to the Vehicle Modification Data Sheet.

**3.1.2.1 Tank.** The stock fuel tank is E85 compatible and shall not be replaced. Inspectors will be checking for the stock tank during the safety inspection. In order to ensure that all vehicles will be receiving the same fuel, vehicles have to arrive at the competition site with no more than 1/8 tank of fuel (3-4 gallons), as shown on the stock fuel gage.

**3.1.2.2 Fuel Lines.** The stock steel fuel lines are ethanol compatible and may be retained. Copper fuel lines are not acceptable. Teams must have (at Safety Inspections) documentation of the ethanol compatibility of non-stock flexible fuel lines.

Fuel lines shall be routed outside of the passenger compartment, within the frame rails and shall maintain a minimum distance of 51 mm (2 in.) away from any moving suspension components (through the full range of travel), and 102 mm (4 in.) from any shielded exhaust components. Lines shall be supported every 610 mm (24 in.) by corrosion-resistant hangers (stock hangers are acceptable). Lines shall be routed so that they do not come in contact with the vehicle (except at mounting points) and are protected from road debris (use shielding where necessary).

**3.1.2.3 Flame Arrestors.** Each competition vehicle shall be equipped with a flame arrestor of student design. Each competing team shall submit a Flame Arrestor Design Report to Cindy Svestka by COB December 10, 1999. These reports will be reviewed by GM and ANL personnel.

Teams whose flame arrestor designs are deemed inadequate will be notified by March 22, 2000. These teams will be required to submit revised designs by April 15, 2000. Teams whose flame arrestors do not meet the flow requirements at the competition



**will receive an automatic 25-point penalty.** These teams also risk losing points associated with the On-Road fuel economy events since precise refueling will not be possible.

**3.1.2.4 Fuel Drain.** The fuel tank will be drained using the stock Schraeder valve (found on stock engine fuel rail) and the vehicle's fuel pump. If a non-production fuel rail configuration is utilized, the stock Schraeder valve must be in place. Likewise, if a non-production fuel relay and wiring (to energize the fuel pump) is used, then the fuel pump relay must be located in the engine compartment and be clearly labeled.

### **3.3 Engine**

The engine can be modified to optimize E85 utilization, but the engine block must be the same type as the original (Gen. III GM Small Block V-8). If any damage occurs during the conversion or the Challenge, the repair costs will be the responsibility of the college or university team.

### **3.4 Suspension**

Modification to the vehicle suspension will be allowed only if 1) the ride height is not modified and 2) the stock suspension type is not changed (i.e., – components may be replaced with only LIKE components). The ride height and suspension system will be reviewed for concurrence to this rule during the safety inspection portion of the competition.

### **3.5 Body and Aerodynamics**

No modifications to the “body in white” will be allowed, unless required to safely install emission-control equipment. Hoods may be modified if justifiable for conversion safety. Aerodynamics improvements will be allowed if these changes do not nullify the “Silverado” look of the vehicle. Bed Covers will not be allowed during the On-Road Fuel Economy portion of the Challenge. An award for Best Vehicle Appearance will be given at the end of the competition. Teams must justify any proposed modifications by submitting a schematic plan and rationale for the modification to Cindy Svestka for review by the Technical Committee.

### **3.6 Frame Modifications**

No modifications to the frame will be permitted, unless required to safely install emission-control equipment. Teams must justify any proposed modifications by submitting a schematic plan and rationale for the modification to Cindy Svestka for review by the Technical Committee.

### **3.7 Exhaust System**

Teams earn points for reduced exhaust emission levels, as measured by the standard Federal Test Procedure (FTP) for emissions. Changes to the production exhaust emissions control system are allowed. Appropriate heat shielding for the catalytic converter and other relevant exhaust-system components is required for safety and must meet the requirements in the Vehicle Safety Inspection Sheet.

The exhaust system must meet applicable 1988 U.S. Federal Standards for exhaust emissions to earn points in the emissions event, as described in Section 5.3. Also, the acceptable vehicle noise level will be 80 dB. Penalty points will be assessed for vehicles exceeding this limit, as described in Section 5.11.

### 3.8 Wheels and Tires

Only wheels which have the stock dimensions (Steel -16 in. x 6.5 in. with 31 mm offset, Aluminum – 16 in. x 7 in. with 31 mm offset) and meet the requirements of the Wheel and Rim Manufacturers Association may be used in Challenge events. Any commercially available P265/75R16 type of tire (any manufacturer) may be used.

Tire pressures will be limited to the maximum pressure as stated on the sidewalls or to the manufacturer recommendation as stated in a letter from the manufacturer (Letters indicating a recommended tire pressure other than stated on the sidewalls must be submitted to Cindy Svestka on or before April 1, 2000). Teams may not modify their vehicle's tire type and/or tire pressure after the vehicle passes the technical inspection, however the Organizers will modify the tire pressures of all vehicle to the maximum level for the Trailer Towing portion of the Fuel Economy Event. The tire pressure selected by each team at inspection will be noted on their vehicle; that pressure must be maintained for all events except Trailer Towing. The Organizers reserve the right to alter tire pressures to within acceptable limits at any time during the competition for safety.

A minimum tread depth of 4 mm (5/32 in.) across the entire width of the tire will be required for safety. The same wheels and tires must be used for all events. The spare tire must be in the stock position or safely located in an accessible location.

### 3.9 Transmission and Final Drive

All vehicles are delivered with an electronically-controlled four-speed automatic transmission. If teams wish to make changes, a schematic plan and rationale for the proposed modifications must be submitted to Cindy Svestka for review by the Technical Committee.

### 3.10 Engine Control System

The Engine Control System (i.e. sensors & wiring), may be modified. Any type of system configuration using a new Engine Control Module (production GM Powertrain Control Module (PCM) excluded) will be permitted. Modifications to the stock production GM PCM will only be allowed via the **PCM Calibration Update Process**. "Piggyback" systems may be used as long as they do not overload any existing circuit in the control. Documentation of the function of all piggyback systems (including location and schematics) should be included as an attachment to the Vehicle Modification Data Sheet. One and only one control strategy will be permitted per vehicle. Modification to the engine setup will not be permitted after the vehicle passes the technical inspection and is ready to

compete in any dynamic event. Any team making such a modification will be disqualified from that event and all remaining events.

### ***PCM Calibration Update Process***

Teams may also opt to participate in the PCM Calibration Update process organized by GM. Participation in this process is voluntary. Teams must fill out Appendix F and return to Cindy Svestka no later than November 1, 1999. Teams electing to participate agree to follow the guidelines and rules as defined in the PCM Calibration Update Guide.

#### **3.11 Component Deletion**

Except for the gasoline fuel system, removing components or systems (air conditioning, cruise control, heater, crankcase ventilation system, etc.) from the vehicles is prohibited. No changes are allowed that would nullify compliance with federal, state, or provincial safety regulations. All vehicles must have all systems that came with them in good operating condition, but systems may be modified as long as safety is not compromised. **Any non-working system or component (excluding the gasoline fuel system) will incur a 25-point penalty per component or system.**

#### **3.12 Communications Equipment**

All vehicles and support vehicles must be equipped with a 40-channel CB radio. It is the team's responsibility to obtain and install the CB radio in the vehicle. Vehicles without a CB radio will not be permitted to run in the on-road fuel economy event or other road event (if applicable). The official CB channel for the Challenge Road Trip will be 33.

#### **3.13 Fire Extinguisher**

All vehicles must have a 5-lb. (minimum) class ABC fire extinguisher onboard. It must be readily accessible to a belted-in driver and securely mounted. Teams must provide metal mounting brackets that are sufficiently strong to retain the extinguisher in the event of a collision.

#### **3.14 Operation of Additional Control Features**

All engine and driveline control systems must be passive and operate without driver intervention. All gauges, indicators, connectors, and switches must be labeled. Existing switches or controls cannot be shared to operate engine and/or driveline control functions. In addition, switches or devices that might change or defeat the engine setup will not be allowed. Teams should be prepared to present component descriptions and wiring diagrams at safety/technical inspections if requested.

**A 25-point minimum penalty will be assessed for identified discrepancies, however the safety/technical inspection team reserves the right to enforce stiffer penalties for these violations up to and including disqualification from the competition.**

### 3.15 Vehicle Modification Data Sheets

All teams must submit a complete and accurate 2000 Ethanol Vehicle Challenge Vehicle Modification Data Sheet (see Appendix D) to Cindy Svestka at Argonne National Laboratory by **5 p.m. CST on April 28, 2000**, or the school will be ineligible for competition.

### 3.16 Vehicle Appearance

Organizer provided Sponsor Decals must appear on the competition vehicles as described in the following sections (see Figure 1 for decal placement diagram). Other graphics are acceptable, but they must be in good taste. No graphics, except those supplied for window application (e.g., sun shades), may appear on any window, and no obstruction of vision of any sort is allowed. Individual graphics, and graphics from other sponsors, are limited to 250 cm<sup>2</sup> (40 in.<sup>2</sup>) per decal. There will not be an official color for the vehicles. A special award for the vehicle with the best appearance will be presented by the Organizers.

**3.16.1 Vehicle Graphics and Decals.** Vehicle graphics and decals, that may be applied to the competition vehicles, are specified below.

**3.16.1.1 Graphics and Lettering Size.** Other than vehicle numbers, school name, and Competition logo, no lettering may be greater than 8 cm (3.1 in.) high. In addition, no lettering or graphics may be greater than 250 cm<sup>2</sup> (40 in.<sup>2</sup>) in area. Also, schools shall reserve the front fenders and front doors for competition sponsor logos.

**3.16.1.2 Competition Logo.** 2000 Ethanol Vehicle Challenge identification and logo decals will be provided by the Organizers and should be placed on the top portion of the front doors on each side of the vehicle. The logo decal will measure 22.9 cm (9 in.) high and 70.0 cm (24 in.) wide and must have at least 5 cm (2 in.) of unobstructed color on all sides.

**3.16.1.3 Competition Sponsor Decals.** Competition sponsors support the entire competition, not just individual schools. The design and manufacture of the Competition Sponsors' decals will be the responsibility of the Sponsor. Competition Sponsors are also responsible for sending their decals to competition Organizers at Argonne National Laboratory (ANL). ANL will collect all sponsor decals and forward them, along with detailed application instructions, to all participating teams.

The Organizers will require that teams put decals from certain competition sponsors on their vehicles, and teams must reserve the front fenders and front doors of the vehicle for this purpose. Teams are free to place local sponsor decals on all other (non-reserved) locations of their vehicles, provided that all specifications regarding vehicle markings are strictly followed. Decal size specifications and location will be determined by Sponsor classification: Headline Sponsor, Major Competition Sponsor or Competition Supporter.

**3.16.1.4 Headline Sponsor Decal Specifications.** Two decals per Headline Sponsor are required to be displayed (one on each side of the vehicle on a vertical surface). Each decal must not be larger than 232 cm<sup>2</sup> (approx. 36 in.<sup>2</sup>).

**3.16.1.5. Major Competition Sponsor Decal Specifications.** Two decals per Major Competition Sponsor are required to be displayed (one on each side of the vehicle on a vertical surface). Each decal must not be larger than 130 cm<sup>2</sup> (approx. 20 in.<sup>2</sup>).

**3.16.1.6. Competition Supporter Decals.** One decal per Competition Supporter is required to be displayed. Each decal must not be larger than 78 cm<sup>2</sup> (approx. 12 in.<sup>2</sup>).

**3.16.1.7. Local Sponsor Decals.** Local Sponsors support individual teams. Local Sponsor decals may be placed on the truck bed's fenders and/or tail-gate. However, they may not be larger or more prominent than the Major Competition Sponsor decals. Each Local Sponsor is permitted to have one decal on each side of the vehicle, and one decal on the tail-gate OR hood of the vehicle (only use the hood for local sponsors' decals if no space remains on the tail-gate), for a total of three decals per vehicle. If a team has a local sponsor that is a direct competitor (e.g. Ford, Toyota, etc.) of the competition vehicle sponsor, that local sponsor's decals may not be placed on the competition vehicle (see section 2.7.4). However, teams may use a 13 in. high by 24 in. wide box on the left-hand portion of the tail-gate for these sponsors' names. Names listed in this area may appear only once and should be listed under the heading, "Additional Support Provided by:," and lettering may be at most 2.54 cm (1 in.) high, 2 cm (0.8 in.) wide, and have a brush stroke of no more than 0.5 cm (0.12 in.).

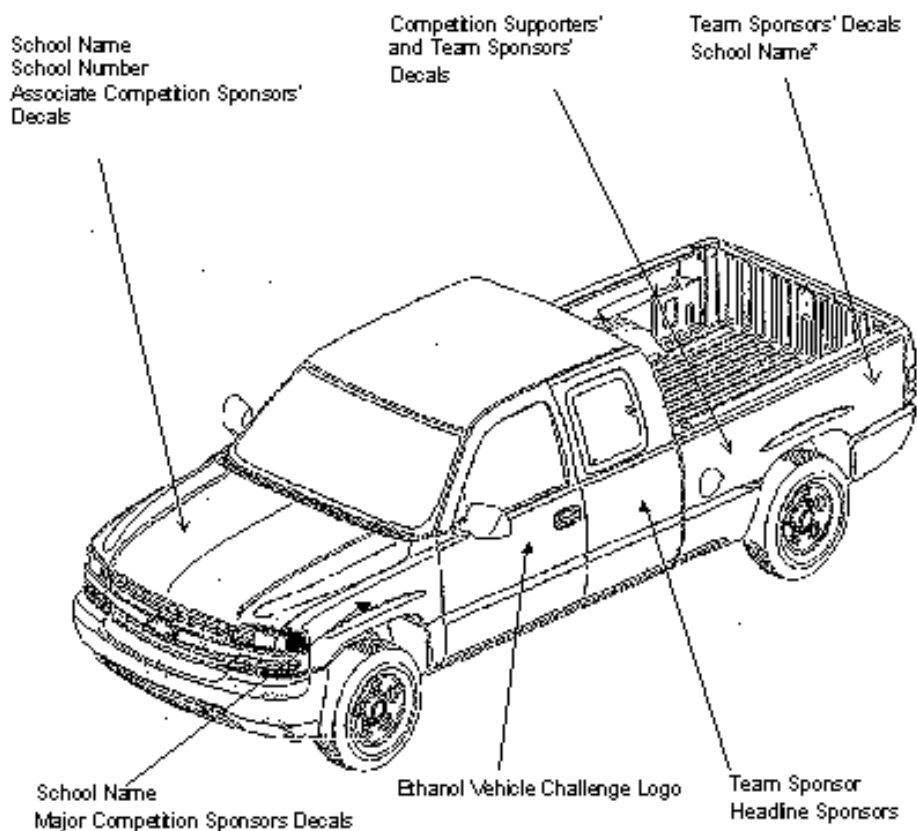
**3.16.1.8 Vehicle Numbers.** The school's team number must be displayed on both of the rear doors of the vehicle. The numbers must be at least 25 cm (9.8 in.) high and 12 cm (4.7 in.) wide and have a brush stroke of at least 4 cm (1.6 in.). The number must be displayed on an unobstructed background of a contrasting color with a border of at least 5 cm (2 in.) on all sides. The colors can be black on white, white on black, or other high-contrast colors approved by the Organizers.

The numbers for the teams for the original 14 teams were chosen randomly in the first year of the Ethanol Vehicle Challenge. Numbers for Team Truck and the two Canadian Collaboration schools were assigned in 2000. The vehicle numbers are:

- 00 – Team Truck
- 01 – University of Waterloo
- 02 – University of Texas at El Paso
- 03 – Kettering University
- 04 – University of Nebraska-Lincoln
- 05 – Cedarville College
- 06 – Crowder College
- 07 – Idaho State University
- 08 – University of California, Riverside
- 09 – Wayne State University
- 10 – Minnesota State University, Mankato
- 11 – University of Illinois at Chicago
- 12 – Illinois Institute of Technology
- 13 – University of Texas at Austin
- 14 – University of Kansas
- 15 – University of Alberta
- 16 – University of Windsor

**3.16.1.6 School Names.** School names or approved abbreviations are mandatory and must be located on the hood, both sides, and the tail-gate of the vehicle. The lettering on the sides must be at least 8 cm (3.1 in.) in height with a brush stroke of 2 cm (0.8 in.). The lettering on the front and back must be at least 5 cm (2 in.) in height with a brush stroke of 1.5 cm (0.6 in.).

Figure 1. Sponsors' Logo Decal Placement



- Ethanol Vehicle Challenge Logo MUST be on the TOP panels of the doors.
- Decals indicated for placement on one side of the vehicle should be mirrored on the other side.
- All competition sponsors' decals will be supplied.
- Individual team sponsors' decals are limited to 250 cm<sup>2</sup>
- \*School name must appear on the vehicle hood and on both sides of the vehicle (front, rear, or middle).

## **4 CONDUCT OF THE EVENT**

### **4.1 General**

The 2000 Ethanol Vehicle Challenge is an engineering research competition, not a race. At any time during the competition, violation of the intent of the rules will be considered a violation of the rules. Any rule relating to safety is final, and person(s) that do not comply with the rules will be removed from the event. The Organizers assume that all team members participating in the Ethanol Vehicle Challenge are familiar with the rules.

### **4.2 Safety**

The overriding emphasis of the Ethanol Vehicle Challenge is safety. Any unsafe behavior during the events will result in disqualification of the student team. All teams must submit a Vehicle Modification Data Sheet (Appendix D) signed by the faculty advisor, and all vehicles must undergo a stringent safety inspection before being allowed to compete (see for Appendix B for a sample Vehicle Safety Inspection Sheet).

### **4.3 Hazardous Materials**

Teams must notify the Organizers in writing of any potentially hazardous or dangerous material that may be contained within the vehicle or support vehicles. Each team must submit a Material Safety Data Sheet (MSDS) for each substance they plan to have on site during the competition to the Organizers no later than April 28, 2000.

### **4.4 Accidents**

Any accident must be reported immediately to an Ethanol Vehicle Challenge Organizer. A list of specific individuals to be contacted and their phone numbers injury and/or property damage, appropriate public safety officials must be notified immediately.

### **4.5 Driver/Team Leader Meetings**

On most days of the competition, meetings will be held at the beginning or end of the day. Attendance is mandatory and limited to the faculty advisor, team leader or any designated substitute, and all drivers who are scheduled to participate in the event(s) of the next day. All official event information and/or statements will be provided during these meetings. Penalty points will be assessed for missed meetings (5 points per absence).

### **4.6 Driving Conduct**

Safety during the competition will be considered the ultimate responsibility of the competitors. Thus, aggressive driving, running trucks off the course, not yielding to passing signals, and other unsafe driving behavior, may result in a loss of points and possible disqualification from the Ethanol Vehicle Challenge.



**4.6.1 Pit Rules.** When a truck is driven in the pits, it must be driven at a walking pace as a team member walks beside it. The walking rule will be enforced, and Ethanol Vehicle Challenge Organizers reserve the right to assess point penalties for violations of this rule.

**4.6.2 Driving Rules.** When the truck must travel on public roads, the driver must obey all traffic laws and drive in accordance with normal rules of the road. The driver and passengers must wear helmets and safety belts whenever such items are required by the event.

**4.6.3 Driving on Public Roads.** Teams must notify the Organizers before driving on any public roads, except during sanctioned events.

**4.6.4 Passing.** Locations where passing is allowed during events will be given at the driver meetings. A driver must signal his/her intent to pass a vehicle by flashing the vehicle's headlights. Turn signals must be used for any lane change or passing maneuver.

#### **4.7 Safety Equipment**

Seat belts and air bags must be fully operational at all times during the competition. Seat belts must be worn by all competition participants whenever they are riding in or driving a competition vehicle. Helmets must be worn by the driver and passenger whenever they are required by the event (e.g., during the acceleration and off-road events). A helmet bearing a 1995 or later Snell Foundation SA or M-sticker is required.

All persons in the pit area must wear safety glasses. Cutoffs, loose clothing, and open-toed shoes will not be permitted in the pit area(s) during the Challenge. **All personal safety equipment must be supplied by the school team.** Schools can share their helmets with other schools if it is necessary. However, the Event Captain must be contacted before the event starts to accommodate this situation.

#### **4.8 Repairs**

All major work on the vehicle must be done in the designated area (pit area). Minor repairs will be allowed in a particular event location with no penalties. If a vehicle needs to be repaired, the time taken to complete the repair will be considered as event time. If the vehicle misses an event, all points for the event may be forfeited. The event organizer will decide if a repair is considered minor and can be performed in the event location. All repairs or modifications done on the vehicle after the safety inspection has been performed need to be approved by a safety inspector. A welding area will be designated for use by the students if it is necessary.

#### **4.9 Support Vehicles**

All support vehicles must be equipped with safety belts at all seating positions. Safety belts must be worn at all times while the support vehicles are in motion.

#### **4.10 Prohibited Substances**

Any use of alcohol during the hours of the event or controlled substances at any time will result in immediate disqualification of the individual. Smoking is prohibited in refueling and pit areas.

#### **4.11 Arbitration of Rulings**

Arbitration of rule interpretation or of protests will be handled at the **end of each day** by a three-person jury, independent of the Event Organizers. A detailed, written description of the contested point must be submitted to one of the event Organizers no later than two hours after the conclusion of the day's competitive events. The majority vote of the jury is necessary to make a ruling. Decisions will be posted the following morning. The jury's decision will be final. In addition, on the basis of the jury's judgment, protests that are denied and are determined to be frivolous may incur a penalty of up to 25 points to the filing team.

#### **4.12 Rules Clarifications**

Any clarifications, modifications or additions to these rules will be posted on the ANL ethanol-challenge mailing list. It is the team's responsibility to be aware of and comply with any rules changes posted on the e-mail system. Teams may subscribe to the mailing list by sending a message with "subscribe ethanol-challenge" in the body of the text to **majordomo@anl.gov** (see Section 2.2 Communication).

### **5 EVENT DESCRIPTIONS**

#### **5.1 Safety Inspection (Pass/Fail)**

Before any vehicle is allowed to participate in any 2000 Ethanol Vehicle Challenge event, it must pass a thorough safety inspection. To pass this inspection, vehicles must conform to the specifications in the Rules and the specific items on the Vehicle Safety Inspection Sheet found in Appendix B. Vehicles failing to conform to the Safety Checklist will not be allowed to participate in any of the 2000 Ethanol Vehicle Challenge dynamic events. Vehicles need to arrive with less than 1/8 tank of fuel (as shown on the stock fuel gauge) at the Safety Inspection site (see Section 3.1.2.1). If an item is found during the inspection that is not in compliance with the minimum safety guidelines set forth in the Vehicle Safety Inspection Sheet, team members will be provided with a written description of the deficiency and will be required to remedy it before they can compete in any of the dynamic events. Teams will not be allowed to participate in any dynamic event until all safety issues are resolved to the satisfaction of the safety officials. Teams missing events as a result of unresolved safety items will lose the points associated with the event. The team is responsible for addressing all safety items at their cost. The Organizers will not provide equipment or a location at which these safety items can be corrected, other than the pits. If teams have any questions about whether a feature on their vehicle is consistent with the guidelines contained in the Vehicle Safety Inspection Sheet, they should submit a written request for interpretation by the

Technical Committee to Cindy Svestka at Argonne National Laboratory no later than April 28, 2000.

## 5.2 EPA Fuel Economy Event (150 points)

Two different fuel-economy measurements will be scored. One score will be calculated from the combined EPA emission tests (Section 5.3), and the other score will be measured from the on-road fuel economy event (Section 5.4). Fuel economy results will be given in liters per 100 kilometers and miles per gallon of E85. To calculate the energy content, a specific heating value of 12,747 Btu/lb - 29 MJ/kg is assumed for the fuel used in this competition.

Fuel economy calculated from the EPA test (EPA-FE<sub>city/hwy</sub>) will be based on a harmonically weighted average of the highway and city results. The weighting will be 55% of the city result and 45% of the highway result. The final EPA fuel economy will be calculated as:

$$\text{EPA-FE}_{\text{city/hwy}} = 1/[(0.55/\text{EPA-FE}_{\text{city}})+(0.45/\text{EPA-FE}_{\text{highway}})].$$

Final scores will be calculated by using the following formula:

$X_{\text{Best}}$  = Vehicle with the highest City/Highway EPA fuel economy;

$X_{\text{Cutoff}}$  = The second standard deviation below the median result, or the vehicle with the lowest City/Highway EPA fuel economy (whichever is greater);  
and

$X$  = Team's result for this event.

If  $X < X_{\text{Cutoff}}$  then  
Score = 0.2 \* Total Points

If  $X \geq X_{\text{Cutoff}}$  then  
Score =  $\left(0.8 * \left[ \frac{X - X_{\text{Cutoff}}}{X_{\text{Best}} - X_{\text{Cutoff}}} \right] + 0.2 \right) * \text{Total Points}$

No negative points will be awarded in any of the fuel economy events.

## 5.3 Exhaust Emissions Event (200 points)

Testing will be performed in accordance with the Cold-Hot Start weighted City Federal Test Procedure (FTP). Teams may earn up to 200 points for emission performance of the vehicles on the basis of the simultaneous control of pollutants, as listed in Table 1. A team is not eligible to win the Best Fuel Economy Award or the Best Conversion Award if it fails to meet the forty points score bracket in Table 1.

**Table 1. 2000 Ethanol Vehicle Challenge Emissions Scoring**

	(g/mil) NMHC	(g/mil) CO	(g/mil) NOx	Points
	>0.8000	>10.0000	>1.7000	0
<b>Fed 1988</b>	0.8000	10.0000	1.7000	40
	0.7250	9.7500	1.5250	45
	0.6500	9.5000	1.3500	50
	0.5750	9.2500	1.1750	55
<b>Fed Tier 0</b>	0.5000	9.0000	1.0000	60
	0.4775	8.4250	0.9625	65
	0.4550	7.8500	0.9250	70
	0.4325	7.2750	0.8875	75
	0.4100	6.7000	0.8500	80
	0.3875	6.1250	0.8125	85
	0.3650	5.5500	0.7750	90
	0.3425	4.9750	0.7375	95
<b>Fed Tier 1</b>	0.3200	4.4000	0.7000	100
	0.3000	4.4000	0.7000	105
	0.2800	4.4000	0.7000	110
	0.2600	4.4000	0.7000	115
	0.2400	4.4000	0.7000	120
	0.2200	4.4000	0.7000	125
	0.2000	4.4000	0.7000	130
	0.1800	4.4000	0.7000	135
<b>CARB TLEV</b>	0.1600	4.4000	0.7000	140
	0.1525	4.4000	0.6625	145
	0.1450	4.4000	0.6250	150
	0.1375	4.4000	0.5875	155
	0.1300	4.4000	0.5500	160
	0.1225	4.4000	0.5125	165
	0.1150	4.4000	0.4750	170
	0.1075	4.4000	0.4375	175
<b>CARB LEV</b>	0.1000	4.4000	0.4000	180
	0.0875	3.8500	0.4000	185
	0.0750	3.3000	0.4000	190
	0.0625	2.7500	0.4000	195
<b>CARB ULEV</b>	0.0500	2.2000	0.4000	200

\* NMHC (Non-Methane Hydrocarbons) will be used (facilities permitting) as the HC measurement for this event. This measurement includes aldehydes and concentration of alcohols.

#### 5.4 On-Road Fuel Economy (75 points)

On-road fuel economy will be measured on public roads, and the event will consist of two parts: Trailer Towing and Highway (see details below). Teams will be required to maintain the posted speed(s) in each portion of the Event; teams that cannot or choose not to maintain the posted speeds will incur penalties (described below) and will not be eligible for the Fuel Economy Award.

##### Trailer Towing

The Trailer Towing portion of the On-Road Fuel Economy Event will be driven at posted speeds on public roads. During this event, each vehicle will be refueled to full and have a 6000lb trailer attached. The vehicles will be driven approximately 45 miles (72.4 km) on a route through the Gatineau Hills Park, beginning and ending at Natural Resources Canada. The vehicles will then be precisely refueled. The total amount of fuel consumed per vehicle during this portion of the Fuel Economy Event will be measured and recorded. If a team vehicle can not or chooses not to maintain posted speeds (local traffic permitting), the team will lose 25% of the total points earned in the On-Road Fuel Economy Event.\*

##### Highway

The Highway portion of the On-Road Fuel Economy Event will take place en-route from Ottawa to Oshawa, Ontario. Vehicles will be unballasted on this 242-mile (389.5 km) trip. Prior to departing for and upon arrival in Oshawa, vehicles will be precisely refueled. The total amount of fuel consumed per vehicle during this portion of the Fuel Economy Event will be measured and recorded. Local traffic conditions permitting, team vehicles will be required to maintain posted speeds. If a team vehicle cannot or chooses not to maintain posted speeds, the team will lose 25% of the total points earned in the On-Road Fuel Economy Event.\*

\* These penalties are cumulative, meaning that if a team does not maintain posted speeds in **both** sections of the event, they will lose 50% of the total points earned in the On-Road Fuel Economy Event.

Fuel economy calculated from the On-Road fuel economy test (On-Road-FE<sub>loaded/unloaded</sub>) will be based on a harmonically weighted average of the loaded and unloaded results. The weighting will be 55% of the Trailer Towing result and 45% of the Highway result. The final On-Road fuel economy will be calculated as:

$$\text{On-Road-FE}_{\text{loaded/unloaded}} = 1/[(0.55/\text{On-Road-FE}_{\text{loaded}})+(0.45/\text{On-Road-FE}_{\text{unloaded}})]$$

Final scores will be calculated by using the following formula:

$X_{\text{Best}}$  = Vehicle with the highest On-road fuel economy;

$X_{\text{Cutoff}}$  = The second standard deviation below the median result, or the vehicle with the lowest On-road fuel economy (whichever is greater); and

$X$  = Team's result for this event.

If  $X < X_{\text{Cutoff}}$  then  
 Score =  $0.2 * \text{Total Points}$

If  $X \geq X_{\text{Cutoff}}$  then  
 Score =  $\left( 0.8 * \left[ \frac{X - X_{\text{Cutoff}}}{X_{\text{Best}} - X_{\text{Cutoff}}} \right] + 0.2 \right) * \text{Total Points}$

No negative points will be awarded in any of the fuel economy events.

## 5.5 Cold-Start Time Event (75 points)

Vehicles will be tested for cold-start performance in two segments: cold-start (time) and driveability. This is the first of the two segments. Cold-start (time) will occur between 8-24 h after shutdown; the vehicle will be preconditioned before the cold-start soak. Cold soak will be at 0 degrees F. The amount of time before the vehicle starts will be measured for this event.

All starts will be conducted as follows. The vehicle will be powered up but not started for two seconds at which time the key will be turned to start. The first start attempt will terminate either when the rater feels the vehicle has started or at 10 seconds. If the vehicle does not start in 10 seconds, the key will be turned and a second 10-second start attempt will be made. If that attempt fails, a third attempt will be made. If three 10-second attempts fail, a no-start is declared. At that point, the vehicle will be started by other methods, such as pumping the fuel pedal.

To be considered a valid start, the engine must engage and stay running until the engine is put into drive. If the engine stalls in this period, the restart time will be added to initial start time (and any previous restarts) to obtain the total start time.

$X_{\text{Best}}$  = Vehicle with the lowest cold start time measurement;

$X_{\text{Cutoff}}$  = The second standard deviation plus the median result, or the vehicle with the greatest time (whichever is smaller); and

$X$  = Team's result for this event.

If  $X > X_{Cutoff}$  then

$$\text{Score} = 0.2 * \text{Total Points}$$

If  $X \leq X_{Cutoff}$  then

$$\text{Score} = \left( 0.8 * \left[ \frac{X - X_{Cutoff}}{X_{Best} - X_{Cutoff}} \right] + 0.2 \right) * \text{Total Points}$$

## 5.6 Cold-Start Driveability Event (75 points)

All vehicles will be driven under the same conditions by one driver in order to measure the driveability of the vehicle, as compared with that of a similar gasoline vehicle. The driveability test (segment 2 of cold testing) will be conducted according to the procedure outlined in Appendix E. Driveability will be evaluated after the cold start, and will be judged from the point when the vehicle is placed in gear and begins to move. All evaluations will be carried out on the road. Results from this procedure are rated as demerits, so higher scores mean worse driveability.

This segment begins at the same time as the starting test. While start time will not figure into the demerit score, stalls in park do count in the calculation of driveability demerits. If the truck can not be started, no points are received in this segment.

The scoring will be based on the following equation:

$X_{Best}$  = Vehicle with the lowest score from the judge;

$X_{Cutoff}$  = The second standard deviation plus the median result, or the vehicle with the greatest score from the judge(whichever is smaller); and

$X$  = Team's raw result for this event.

If  $X > X_{Cutoff}$  then

$$\text{Score} = 0.2 * \text{Total Points}$$

If  $X \leq X_{Cutoff}$  then

$$\text{Score} = \left( 0.8 * \left[ \frac{X - X_{Cutoff}}{X_{Best} - X_{Cutoff}} \right] + 0.2 \right) * \text{Total Points}$$

## 5.7 Off-Road Event (50 points)

The Off-Road Event evaluates the trucks' maneuverability and handling qualities on an off-road course. The off-road course will combine the performance features of acceleration, braking, and handling in one event. This will be a timed event.

The timer will not start until the front tires break the starting line photocell beam, and will stop when the front tires break the finish line photocell beam.

Each team will be allowed two (2) runs and may have a driver change if they desire. All competing vehicles will be staged in the staging area prior to event and a “parade/inspection lap” will be run with all drivers in the competing vehicles at that time. One (1) driver and one (1) navigator will be the only occupants permitted in the vehicle during each run. Helmets bearing a 1995 or later Snell Foundation SA or M sticker are required for both vehicle occupants.

Vehicles will complete the Off-Road course with the purpose of matching a target completion time. A three (3) second penalty will be assessed for each second early the course is completed. The length of the course will be approximately 1.25 mile (2.0 km). Vehicles will be required to negotiate the course in 4-wheel drive (4WD). Any wheel spin during the initial launch (starting line), neutral slams, or brake torquing will result in 5 penalty seconds being added to the team’s elapsed time.

The speed limits for the course will be posted along the course route. Course speed will be identified based on road conditions.

No stopping allowed on the course. A minimum speed of 10 mph must be maintained for the duration of the course.

Due to the course layout and unknown weather conditions, the speeds may have to be adjusted for safety. Maps of the course, with target completion time and maximum and minimum speeds, as well as a verbal description of the event will be covered in the Team Leader/Driver’s meeting on Thursday, May 18, 2000.

The Off-Road Event score is based on the best elapsed time of the two runs (the one closest to the target) plus penalties.

The scoring will be based on the following equation:

$X_{\text{Best}}$  = Vehicle with the lowest time;

$X_{\text{Cutoff}}$  = The second standard deviation plus the median result, or the team with the greatest time (whichever is smaller); and

$X$  = Team’s result for this event.

If  $X > X_{\text{cutoff}}$  then

Score =  $0.2 \times \text{Total Points}$



If  $X \leq X_{\text{Cutoff}}$  then

$$\text{Score} = \left( 0.8 * \left[ \frac{X - X_{\text{Cutoff}}}{X_{\text{Best}} - X_{\text{Cutoff}}} \right] + 0.2 \right) * \text{Total Points}$$

## 5.8 Written Design Report (100 points)

All teams must submit a written report describing their ethanol conversion strategy and implementation for the 2000 Ethanol Vehicle Challenge. The report must address, at a minimum, the following vehicle information:

- Ethanol compatibility of fuel system components.
- Powertrain configuration (including engine, transmission, and PCM or aftermarket controller specifications).
- Emissions control system(s).
- Fuel economy strategy.
- Cold Start/Driveability improvement systems(s).
- Performance enhancements.
- Project Timeline/Team Management.
- Other vehicle system modifications (suspension, wheels, etc.).
- Cost of implementing modifications on a mass production scale.
- Performance projections, including all actual component and vehicle test results.

The standard SAE technical paper format must be used. The criteria listed in Design Judging (Section 5.11) should be considered when writing the conversion report. Please note that the SAE standard requires the use of both metric (primary) and English (secondary) units of measure.

The report is evaluated on the content as well as the mechanics which are worth up to 25% of the total points. Mechanics include: effective abstract, organization of paper, effective use of figures, graphs, and tables, effective summary, and clarity and accuracy of writing. Technical reports may be published in an SAE Special Publication as a record of the competition, and therefore must be in SAE format. SAE Author kits will be available upon request only. If a school fails to submit the paper in SAE format a penalty of 10% of total available points will be assessed.

A strict limit of 15 pages, including attachments, will be enforced. ***The faculty advisor must sign the paper prior to its submittal. Thirty bound copies and 1 unbound copy of the paper must be received by Cindy Svestka no later than 5 p.m. CST on April 28, 2000.*** The reports will be judged by a panel of industry and government experts. Late papers will not be judged and, therefore, will receive no points for this event; absolutely no excuses will be accepted.

The scoring for this event will be based on the following equation:

$X_{Best}$  = Highest average score from the judges;

$X_{Cutoff}$  = The second standard deviation below the median result, or the team with the lowest average score from the judges (whichever is greater); and

$X$  = Team's raw result for this event.

If  $X < X_{cutoff}$  then

Score =  $0.2 * \text{Total Points}$

If  $X \geq X_{Cutoff}$  then

$$\text{Score} = \left( 0.8 * \left[ \frac{X - X_{Cutoff}}{X_{Best} - X_{Cutoff}} \right] + 0.2 \right) * \text{Total Points}$$

### 5.9 Oral Presentation (100 points)

Up to two members from each team shall make a 15 minute oral presentation of the rationale and approach to their conversion, fuel economy, emission control, and cold-, driveability, and performance-enhancement strategies. A five-minute question and answer session will follow the presentation. Each team's oral presentation will be judged on its content, format, and delivery. Presentations are expected to be of professional quality.

Visual aids are strongly recommended for the Oral Presentation Event. All presentations must be in Microsoft PowerPoint 97 format. Teams must provide a disk containing their presentation to the Organizers no later than the beginning of the Skit Night Event (Wednesday, May 17, 2000. Presentations will be loaded onto a computer in the Oral Presentation room in advance of the presentations. A GM Canada technical staff person will be available during the event to assist with each presentation.

Only the presenting student team will be allowed to watch the presentation. (Organizers reserve the right to invite observers, however, no other participating team(s) will be invited.) For the purposes of providing feedback to the teams, all of the presentations will be videotaped. One copy of the tape will be provided to each team after the competition. Points for this event will be determined using the formula found in Section 5.8.

### 5.10 Design Judging (100 points)

A panel of industry experts will judge each vehicle conversion on points such as:

- Fuel storage and delivery system,
- Engine management system,
- Emissions control system,

- Fuel delivery and induction system,
- Degree of systems integration,
- Level of complexity/production feasibility,
- Execution of concept/craftsmanship,
- Innovative design for improving fuel economy,
- Innovative design for emission control,
- Innovative design for improving power density.

Teams may designate up to three representatives to give a presentation to the design judges during the Design Review Event. Although the Design Review will take place in a garage atmosphere, a professional style design presentation is expected. Teams will have 10-15 minutes for their presentations, then the judges will have 5-10 minutes to ask questions. No team members other than the presentation team will be allowed to participate in the design judging event. Note that the design judges will have read the conversion reports and will be looking for the aspects of each vehicle featured in the reports. The Design Inspection score sheet was provided to the teams after the 1999 Challenge. Copies of the score sheet are available upon request from Cindy Svestka. The point distribution for this event will be determined using the formula found in Section 5.8.

#### **5.11 Pass-By Noise Test (penalty or bonus points)**

The vehicle noise will be measured using a hand-held dB meter, prior to the acceleration event. Noise will be limited to 80 dB. Teams whose exhaust noise exceeds this standard will be assessed a 5-point penalty for each decibel over the standard to a maximum of 50 penalty points.

Bonus points will be awarded for vehicles meeting a target sound range under 80 dB. Specifically, 5 bonus points will be given to teams whose vehicle noise level is less than 78 dB.

#### **5.12 Acceleration Event (75 points)**

All vehicles will be timed over a 1/4-mile straight-line course from a standing start. In the interest of safety, extreme starting procedures, such as neutral drops, will result in disqualification. Tire pressures must be maintained within their specifications. Tire heating (burnout) will not be allowed before the acceleration run.

Each team will be allowed four runs by up to four drivers; the fastest of the four runs will be used for the team's time. All drivers must wear a helmet bearing a 1995 or later Snell Foundation SA or M sticker. The maximum speed in returning to the start line is 50 kph (30 mph). Violations will result in a 50-point penalty. DNS and DNF receive zero points for this event.

The scoring will be based on the following equation:

$X_{\text{Best}}$  = Vehicle with the lowest time;

$X_{\text{Cutoff}}$  = The second standard deviation plus the median result, or the vehicle with the greatest time (whichever is smaller); and

$X$  = Team's result for this event.

If  $X > X_{\text{Cutoff}}$  then

Score =  $0.2 * \text{Total Points}$

If  $X \leq X_{\text{Cutoff}}$  then

Score =  $\left( 0.8 * \left[ \frac{X - X_{\text{Cutoff}}}{X_{\text{Best}} - X_{\text{Cutoff}}} \right] + 0.2 \right) * \text{Total Points}$

## 6 EVENT SCORING

Event	Points
<i>Emissions</i> (Section 5.3)	200
<i>Design</i>	
Written design report (Section 5.8)	100
Vehicle design inspection (Section 5.10)	100
Oral design presentation (Section 5.9)	100
<i>Fuel Economy</i>	
On-road fuel economy (Section 5.4)	75
EPA (55% City/45% Hwy) (Section 5.2)	150
<i>Cold Start</i>	
Time (Section 5.5)	75
Driveability (Section 5.6)	75
<i>Performance</i>	
Acceleration (Section 5.12)	75
Off-Road (Section 5.7)	50
Noise Test (Section 5.11)	Bonus/Penalty Points
<b>Total Points</b>	1000

Event point totals and times will be rounded to the nearest tenth of a unit before using any scaling formulas. Rounding follows the rule that any variance of the unit less than or equal to 0.5 and greater than 0.0 rounds down to the next whole unit. Variances greater than 0.5 and less than or equal to the next greater whole unit round up. These rounding rules do not apply to emissions numbers. For the rounding of emissions numbers, ASTM rounding rules apply.

## 7 AWARD STRUCTURE

Overall final standings and special prizes will be awarded as follow:

First Place Overall	\$4,000
Second Place	\$3,500
Third Place	\$3,000
Fourth Place	\$2,500
Fifth Place	\$2,000
Best Oral Presentation	\$1,000
Best Vehicle Appearance	\$ 500
Best Ethanol Conversion (1/2 paper, 1/2 inspection)	\$1,500
Lowest Emissions (regulated constituents from FTP test)	\$2,000
Best Fuel Economy (average of the two events)	\$2,000
Most Innovative Component Award	\$1,000
Best Cold Start Performance	\$1,000
Simon Vega Sportsmanship Award	\$ 500
<b>TOTAL</b>	<b>\$24,500.00</b>

A Trophy (only) will be awarded for the Best Skit.

## 8 EVENT SCHEDULE

The Schedule for the competition is posted on the web at:

<http://www.transportation.anl.gov/ttrdc/evc2000/calendar.html>

The Schedule is not final and may be modified as necessary by the Organizers. Any change in the schedule will be announced on the Ethanol Vehicle Challenge e-mail list server, or announced to the teams at the Challenge.

# APPENDIX A

## 2000 Ethanol Vehicle Challenge

### TEAM DATA SHEET

School Name \_\_\_\_\_

Faculty Advisor \_\_\_\_\_

Address \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Phone \_\_\_\_\_

FAX \_\_\_\_\_

E-Mail \_\_\_\_\_

Contact Name (if other than Advisor) \_\_\_\_\_

Contact Number (if other than Advisor) \_\_\_\_\_

### Team Members:

[illegible]

Please print or type. Add additional sheets if necessary.

**APPENDIX B**  
**2000 Ethanol Vehicle Challenge**  
**VEHICLE SAFETY INSPECTION SHEET**

**TECHNICAL INSPECTION**

*This form must be filled out along with a visual inspection of the vehicle. A member of the team should respond to the question until it becomes completely clarified.*

Vehicle Number : \_\_\_\_\_ Date: \_\_\_\_\_

University Name: \_\_\_\_\_

TECHNICAL INSPECTION CO-CAPTAINS: JOHN FIRMENT  
 GUY PINARD

TECH TEAMS

<b>BASIC INFORMATION</b>	A	B	C	<b>Comments</b>
Odometer Reading(mi/km)				
Vehicle Registration & VIN Match				
Proof of Insurance				
<b>Helmets – Snell 95 M or Sa Minimum</b>				
Declared Tire Pressures (psi)				F) _____ R) _____ Max Sidewall _____

TECH TEAMS

<b>VEHICLE BODY</b>	A	B	C	<b>Comments</b>
Ride height – Front / Rear				
No body modifications (except to those approved by the Tech. Committee in advance.)				
No frame modifications (except those approved by Tech Comm in advance.)				
Fire extinguisher (type ABC, 5 lb. minimum) mounted securely				
Hood lock operation				
Doors operation and locks				
Window operation				
Seat belt operation and routing				
Seat adjuster operation				
<b>Air Bag System Functional</b>				
Stickers are the correct size and in the correct position				
Driver's visibility is good and clear				
Trailer Hitch Bolts				

## TECH TEAMS

<b>BRAKE SYSTEM</b>	A	B	C	Comments
Pedal travel				
Pedal firmness				
Brake Reservoir Fluid level				
No fluid leaks				
Parking brake operation				
ABS system functional				
<b>Brake pad wear, 50% minimum remaining F &amp; R</b>				
Brake trailer controller				

## TECH TEAMS

<b>STEERING</b>	A	B	C	Comments
No binding				
No excessive play				
No modifications to hardware				

## TECH TEAMS

<b>ECU / ELECTRICAL</b>	A	B	C	Comments
No open wires or connectors				
No switches or devices that may defeat the engine setup				
Covered battery terminals				
<b>Wires encapsulated in conduit</b>				
Wiring must be minimum of 4" from exhaust & movable components. (inside & outside)				
<b>Laptop controls secured</b>				
<b>Grommets for sheet metal or frame wiring pass-thru</b>				

## TECH TEAMS

<b>POWERTRAIN</b>	A	B	C	Comments
Neutral safety switch operation				
Coolant level				
Engine oil level				
Transmission oil level				
Power steering fluid level				
Hose connections				
<b>Belt tension &amp; condition</b>				
No throttle linkage binding				
Throttle return spring				
<b>"Service engine soon" function</b>				
4 wheel drive operation				
PCM Exchange				
<b>Coolant Thermocouple Test</b>				



## TECH TEAMS

<b>EXHAUST</b>	A	B	C	<b>Comments</b>
No exhaust system leaks				
No exhaust system interference				
<b>Catalytic converter &amp; Exhaust heat shielding</b>				

## TECH TEAMS

<b>VISION</b>	A	B	C	<b>Comments</b>
Wiper operation				
Wiper blade condition				
Washer operation				
Washer fluid level				
Heater and defroster operation				
Air conditioner operation				
No vision obstructions				
Low and high beam operation				
Parking lamps				

## TECH TEAMS

<b>SIGNAL DEVICES OPERATION</b>	A	B	C	<b>Comments</b>
Turn signal				
Hazard light				
Horn				
Brake lights				
Reverse lights				
40-Channel CB radio firmly mounted (Channel 33)				

## TECH TEAMS

<b>WHEELS AND TIRES</b>	A	B	C	<b>Comments</b>
<b>Stock size (16X6.5 – Steel; 16x7 - Aluminum)</b>				
Stock tire size (P265/75R16)				
Tread depth (minimum required is 4 mm across face)				
Spare wheel / tire in good condition				
<b>Tire Mfg.; Load capacity &amp; Temp rating.</b>				
<b>Set Declared Pressure</b>				

## ETHANOL CONVERSION

TECH TEAMS				
FUEL SYSTEM	A	B	C	Comments/Material
<b>Fuel Tanks</b>				
Stock Fuel Tank				
Flame Arrestor				
Tank is securely mounted to the vehicle.				
<b>Tubing</b>				
<b>Ethanol compatible material</b>				
<b>Hose and Hose connections (Fittings)</b>				
Material shall be ethanol compatible				
Fuel lines shall be rated for system pressure				
Fuel system pressure test fitting must be same as production. (Schraeder valve)				
Schraeder valve clearance to adjacent components.				
Fuel lines must not have contact with any underhood component except at fittings				
No routing of lines within 4" from exhaust components				
Lines must be supported every 24" by corrosion-resistant hangers				
Routing must be greater than 2" from suspension & exhaust components through their entire range of travel.				
Lines passing through sheet metal or frame must be grommited to prevent chafing				
Lines should be located or shielded so as to be protected from road debris				
Lines should make no contact with the vehicle other than the hangers				
Lines should be routed greater than eight inches from battery terminals, unless insulated against electrical contact.				

TECH TEAMS				
PROPSHAFT	A	B	C	Comments
Front propshaft removed				

TECH TEAMS				
ADDITIONAL CONCERNS	A	B	C	Comments
Electric Turbocharger				
Air Inlet Heater				
Coolant Cooled EGR				

**APPENDIX C**  
**2000 Ethanol Vehicle Challenge**  
**E85 FUEL COMPOSITION**  
**(85% Ethanol, 15% Indolene)**

Ethanol Content, vol. %	82
Reid vapor pressure, psi	6.2
Water, mass %	0.4
Gross heat of combustion, BTU/lb.	13,935
Net heat of combustion, BTU/lb.	12,747
Research octane number	105
Density	0.78
Carbon mass %	57.92
Hydrogen mass %	13.02
Oxygen mass %	29.06
Conductivity, microS/cm	1.81
pHe	7.6
<i>Nominal Distillation, F</i>	
IBP	143
T10	165
T50	172
T90	174
EP	263

## APPENDIX D

### 2000 Ethanol Vehicle Challenge

## VEHICLE MODIFICATION DATA SHEET

(Add any number of extra pages necessary)

Please fill in the blanks with information that best describes your system. If a section has not been modified, fill the space with "STOCK" to indicate that the OEM part is been used. The Faculty Advisor and Team Leader must sign the bottom of the document. The completed Vehicle Modification Data Sheet is due to Cindy Svestka on April 28, 2000.

### Team Information

Vehicle Number: \_\_\_\_\_  
 University Name: \_\_\_\_\_  
 Team Leader: \_\_\_\_\_  
 Faculty Advisor: \_\_\_\_\_

### A ENGINE

#### General

Displacement	
Bore	
Stroke	
Compression ratio	

#### Piston

Material and description of piston face	
Number/size/type/material of piston rings	

#### Cylinder head

Manufacturer and model number			
Type/material			
Combustion chamber volume and shape			
Porting/combustion chamber mods			
Valve sizes: intake		exhaust	

#### Camshaft

Manufacturer			
Specifications			
Intake: lift		duration at 0.050-in.	
Exhaust: lift			duration at 0.050-in.
Lobe separation			
Tappet type and description			
Rocker arm manufacturer, type and lift ratio			

**Induction** (Include schematic of induction system)

Boosted:      yes              no	
If yes, method of boost, number of boost devices	
Manufacturer	
Intercooled: yes    no	
If yes, manufacturer of intercooler	
Intake manifold type/special features	
Throttle body	
Fuel metering	

**Ignition**

Type and features	
Engine control system changes	
Spark plugs	
Ignition controller (OEM, other, combination?)	

**Exhaust** (Include schematic of exhaust system)

Manifold type	
Pipe diameters	
Configuration	
Insulation:      yes              no	
If yes, include description	

**PCM**

Stock Calibration:      yes              no	
Calibration Level:      5.3-L              4.8-L	
49-State              California	

**Piggyback Controller(s)**

Make	
Model	
Variables	
Describe each piggyback controller's function:	
Attach diagram of placement in vehicle	
Attach mechanical/electrical schematics	

**Emissions Control**

A/F control strategy (in detail)			
When is A/F ratio:			
Run at stoichiometric			
Run lean			
What is A/F ratio for:			
Idle		rpm	
Cold start			
Acceleration			
What approach is used for:			
Power enrichment			
Deceleration			
A/F control computer			
Accessories			
Catalysts			
Type and number of each			
Volume of each catalyst			
Catalyst composition			

Other changes to emissions control system


**B BODY/CHASSIS****Modifications to Frame**

Cleared by the tech. committee?

**Relocation of Components** (shocks, spare tire, etc.)


**Changes to Drivetrain**

Transmission	
Drive Shaft	
Other	

**Modifications to Body**


**C ETHANOL SYSTEM** (Include schematic)**Fuel Lines**

Material	
Size	
Description of line hangers	
Description of fittings	
Fuel System Diagram Attached	

**4 MISCELLANEOUS**

Please describe any modifications or special features not addressed above

I certify that, for the best of my knowledge, the information provided in here is accurate.

Faculty Advisor's Name \_\_\_\_\_

Signature \_\_\_\_\_ Date \_\_\_\_\_

Team Leader's Name \_\_\_\_\_

**APPENDIX E**  
**2000 Ethanol Vehicle Challenge**  
**COLD START AND DRIVEABILITY CYCLE**

- 1) Key on 2 seconds - no crank.
- 2) Attempt to start (10 second max)
  - A) if start in 10 seconds or less go to 3)
  - B) if no start key off and attempt start
    - i) if start in 10 seconds go to 3)
    - ii) if no start key off and attempt to start
      - a) if start in 10 seconds go to 3)
      - b) if no start, start in any way possible
- 3) Idle in park 5 seconds if stall recycle to step 2) but skip step 3)
- 4) Idle in drive for 5 seconds
- 5) 0-15 MPH light throttle accel  
light braking to a stop  
3 second idle  
0-15 MPH light throttle accel  
Cruise at 15 MPH  
light braking to a stop at 0.1 mile  
Idle 3 seconds
- 6) 0-20 MPH WOT accel  
light braking to 10 MPH and cruise  
light braking to a stop at 0.2 miles  
idle 3 seconds
- 7) 0-15 MPH light throttle accel  
light braking to a stop  
idle 3 seconds  
0-15 MPH light throttle accel  
light braking to reach 10 MPH  
cruise at 10MPH to 0.3 mile
- 8) 10-20 MPH light throttle accel  
cruise at 20 MPH  
light braking to a stop at 0.4 miles  
idle for 3 seconds.
- 9) 0-20 moderate throttle accel  
cruise at 20 MPH  
light braking to a stop at 0.5 miles  
idle for 3 seconds.
- 10) Repeat steps 5-9
- 11) Shift to park, key off



### Definitions

Light Throttle is the constant throttle position, and associated initial manifold vacuum required to accelerate from 0-25 mph (0-40 kph) in exactly 9 seconds when the engine is cold.

WOT is defined as the manifold vacuum when the accelerator pedal is pushed to the floor. This value is not 0 in some vehicles.

Moderate throttle is defined as an initial manifold vacuum that is the mean of the light throttle and WOT manifold vacuums.

Crowd is a constant vacuum acceleration performed at the initial manifold vacuum for light throttle accelerations

Detent accelerations are accomplished with the manifold vacuum that just prevents downshift at 25 mph (40 kph) with a cold engine, this is a constant throttle position acceleration.

Snap & hold accelerations are performed by immediately depressing the accelerator pedal to the position that generates the required vacuum and held at that position regardless of subsequent changes in speed or manifold vacuum. This requires practice with each vehicle to be tested

### Malfunctions

Stall- Engine ceases to run.

Hesitation- A temporary lack of power immediately upon throttle opening that is not characteristic of the vehicle's warmed up performance.

Stumble- A temporary reduction in power after throttle opening

Surge- A periodic decrease and increase in power.

Backfire- An 'explosion' in either the intake or exhaust system

Idle roughness- An evaluation of idle quality and smoothness based on vibration in the seat, steering wheel, armrests, and also the sound. The worst idle quality during the evaluation time should be recorded.

### Severity Levels

Trace- Just discernible to raters and unlikely to be noticed by most laymen

Moderate- A level of severity probably noticeable by most laymen

Heavy- Pronounced malfunction that would be obvious to any driver

Extreme- Severe malfunction likely to cause the layman in real driving to discontinue the maneuver in favor of some other action.

Explicitly, TWDs were calculated in the following manner for this report. Each maneuver, malfunction and severity has a weight, the product of these is the weighted demerits for that maneuver. Take only the highest weighted demerits from each maneuver (and the sum of start times and no-starts in the starting area) and sum these over all maneuvers to get TWD.

<b>Severity Weights</b>	
For each start time in up to 3 starting-attempts-in-park	(number of seconds minus 1)
For each no-start in up to 3 starting-attempts-in-park	5
For idle-in-park stalls	number of stalls in the first 3 starting-attempts-in-park
For stall during idle-in-drive before driveway (count only <b>one</b> )	4
For stalls in driving maneuvers and in any of the 4 idles interspersed with the driving maneuvers	1
For an extreme rating	8
For heavy	4
For medium	2
For trace	1
For a clear maneuver	0

<b>Malfunction Weights</b>	
For maneuver stalls	50
For all types of idle stalls	7
For starting time	5
For nostarts	5
For hesitation	2
For stumble	2
For surge	2
For backfire	2
For idle roughness	1

<b>Maneuvers Weights</b>	
For Light Throttle	1
For WOT	2
For Detent	1
For Crowd	1
For idle (including starting)	1

When all the factors are multiplied together, the following charts of demerit levels is generated.

<b>Demerit Levels for Hesitation/Stumble/Surge/Backfire</b>						
<b>Maneuver</b>	<b>Stall</b>	<b>Extreme</b>	<b>Heavy</b>	<b>Medium</b>	<b>Trace</b>	<b>Clear</b>
Light Throttle	50	16	8	4	2	0
Medium Throttle	100	32	16	8	4	0
WOT	100	32	16	8	4	0
Detent	50	16	8	4	2	0
Crowd	50	16	8	4	2	0

<b>For Idle Roughness</b>				
<b>Extreme</b>	<b>Heavy</b>	<b>Medium</b>	<b>Trace</b>	<b>Clear</b>
8	4	2	1	0

<b>For Idle Stalls</b>		
<b>Idle-in-Park</b>	<b>Starting-Idle-in-drive</b>	<b>Other idle (after moderate throttle or at end of test)</b>
7 each	28	7

<b>For Starting</b>	
<b>nostart</b>	<b>slow start</b>
25 each	$(t-1)*5$

The start time,  $t$ , is in seconds.

Only the result (start, start+stall, nostart) of the first three starting attempts in park count toward demerits.

Only the first stall in drive prior to maneuvering counts toward demerits.

Only the first stall in each maneuver, or in each idle subsequent to the start of maneuvers is counted toward demerits.

Only the highest weighted demerit score from each maneuver is counted.

**APPENDIX F**  
**2000 Ethanol Vehicle Challenge**  
**PCM CALIBRATION UPDATE PROCESS SIGN-UP SHEET**

School Name \_\_\_\_\_  
 Team Leader \_\_\_\_\_  
 Faculty Advisor \_\_\_\_\_

**1. In regards to the PCM Calibration Update Process, we elect to (check one):**

- ☐ Participate in the process.
- ☐ NOT participate in the process. The team understands that we will not be eligible for PCM updates, additional technical support via e-mail and conference calls.

**2. GM will provide us one update each for the dyno and vehicle PCM's, based on our following selections:**

**DYNO PCM**

- ☐ As received at beginning of 99 competition
- ☐ Latest team based calibration at end of 99 competition

**VEHICLE PCM**

- ☐ As received 99 gasoline calibration
- ☐ Latest team based calibration at end of 99 competition

Team Leader \_\_\_\_\_ Date \_\_\_\_\_  
 (signature)

Faculty Advisor \_\_\_\_\_ Date \_\_\_\_\_  
 (signature)

**APPENDIX G**  
**2000 Ethanol Vehicle Challenge**  
**STATEMENT REGARDING CONTROL SYSTEM DEVELOPMENT**

\_\_\_\_\_ ( college or university name)

As faculty advisor for the above named school, I certify the following:

No General Motors Corporation proprietary information outside of that provided through the PCM Exchange Program was employed in the development of the control system in our competition vehicle. This includes but is not limited to the following:

- Software listings outside of those supplied through the PCM exchange program;
- Use of CALTools, DPSTools or other GM proprietary calibration tools.

I also certify that no modification has been made to the vehicle that intentionally or unintentionally results in a change to the vehicle's speed limiting capability set originally at 98 miles per hour.

I understand and my team understands that no changes can be made to the vehicle's controls system after technical inspection.

Signed,

\_\_\_\_\_, Faculty Advisor